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ABSTRACT

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A MULTILEVEL ANALYSIS OF CLASSROOM CLIMATE EFFECTS
ON MATHEMATICS ACHIEVEMENT OF FOURTH-GRADE STUDENTS

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Abstract

This study examined the effect of classroom climate on the mathematics achievement of fourth-grade students in Tennessee public schools. The investigation used data obtained from 875 fourth grade students enrolled in 42 classes in 13 public schools. In the first phase of the inquiry, four class climate factors were identified by exploratory factor analyses of 44 items comprising a classroom climate inventory. Four factors were labeled as academic orientation, satisfaction, class tension, and cohesiveness. Subsequent reliability analyses established both student and class level reliability estimates of the climate measures. In the second phase, effects of climate factors on class mean achievement and on relationships between achievement and student variables were assessed with a two-level hierarchical linear model. Results indicated that: 1) class climate factors affect mathematics achievement differently depending on student characteristics; 2) distribution of achievement varies as a function of class climate; 3) climate factors mediate associations between student characteristics and mathematics achievement; and 4) higher and more equitable distributions of achievement exist in classes with higher levels of academic emphases and student satisfaction, as well as in classes with low levels of tension.

INTRODUCTION

Since much of formal education takes place within a group, analysis of class group properties and their relationships to student behavior may contribute to our understanding of factors affecting student learning and may be helpful in designing effective educational diagnosis, intervention, and planning. Study of the school class group is particularly important since, next to the family and the school, it is one of the principal socializing agencies (Fraser, Anderson, & Walberg, 1982).

Researchers who took an early interest in studying school classroom were primarily concerned with interactions between students and between students and teachers (Thomas, 1929; Lewin, Lippitt, & White, 1939; Lippitt, 1940). This interaction was labeled by Withall (1949) as the *social emotional climate* of a class and seven categories were developed to describe it. An increasing number of studies have subsequently focused on assessing the characteristics and impacts of classroom environment (see Moos, 1979a, 1979b; Nielsen & Kirk, 1974; Randhuwa & Fu, 1973; Walberg, 1979). Such studies have typically assumed that "the classroom environment plays a large role in shaping the behavior of its inhabitants" (Hinely & Ponder, 1979, p. 137). This assumption was supported by Kounin and Sherman (1979) who found that both student and teacher behaviors were influenced by classroom environments, concluding that classrooms have a predictable effect on student behaviors and that they can be manipulated by educators to facilitate learning. In their comprehensive review of school-effectiveness studies, Madaus, Airasian, and Kellaghan (1980) found that the processes, press, and atmospheres of schools and classrooms seem to be more highly related to variations in students' measured achievement than do physical resources,

facilities, or status characteristics of teachers. They concluded that social-psychological interactions among students and between students and school personnel, together with the normative characteristics of subcultures within the school, seem to be the most potent source of differences between school influences on students' cognitive performance. More recently, Creemers and Tillema (1987-88) have defined classrooms as social/emotional environments within which certain "frame" or format factors that supply the foundation that underlies academic achievement. They claim that processes occurring within class groups, particularly at the K-12 level, can better explain student cognitive and affective outcomes than can factors at school or community levels. This notion is associated with the differential context hypothesis which holds that differences in student performances result primarily from classroom contextual effects.

Conceptualizations of Classroom Climates

People sense that there are differences in the overall atmosphere of schools and that these differences affect how people behave (Miskel & Ogawa, 1988). Social and behavioral scientists developed the concept of climate to describe the set of internal characteristics (Tagiuri, 1968) that distinguishes one organization from another. The climate of an organization has been defined by Tagiuri (1968) as a relatively enduring quality of the internal environment of an organization that is experienced by its members, influences their behaviors, and can be described in terms of values of a particular set of characteristics of the organization. Forehand (1968), on the other hand, argued that the concept of organizational climate involves at least three sets of variables: (1) environmental variables, which are external to the individual, (2) personal variables, which individuals bring to the job situation, and (3) outcome variables, which are determined jointly by environmental and personal

variables. In Forehand's (1968) view, climate result from an interaction between environmental and personal variables. Such a definition of organizational climate suggests that climate be studied in terms of the interaction of environmental and personal variables, and consider environmental variables in terms of the degree to which they demand or constrain the operation of personal characteristics.

Conceptualization of classroom climate is basically derived from a social psychology literature viewing individual needs as related to social structural variables (Nielsen & Kirk 1974). The literature on the classroom climate is largely rooted in three models: Murray's Need-Press Model (1938), Getzels and Thelen's notion of classroom as social system (1960), and Walberg's (1971) model of classroom environments. In Murray's Model, demands, sanctions, and expectations within an environment (environmental press) give a social system its particular climate. In Murray's view, the learning environment may be seen as a complex of environmental press which, in turn, may be related to a corresponding complex of personal needs. Getzels and Thelen's (1960) model of the class as social system suggested that within school classes, personality needs, role-expectations, and classroom climates interact and predict group behaviors, including learning. In this model, climate develops as a result of the teacher's transactional style, or the way in which role requirements and personality needs are balanced within classrooms. In Walberg's (1971) model, classroom environments are linked with students' aptitudes and instruction in predicting learning outcomes. Walberg (1970) stated that most of the variance in student performance is attributable to the aptitude of learners and learning environments, with only a small part accounted for by instructional variables and by interactions between the three factors. According to Nielsen and Kirk (1974), these well-known models have provided operational definitions of "climate" and have helped

to generate theories about the relationships of class climates to both antecedent and outcome variables.

Through use of these theoretical models, class climate research has focused essentially on what is termed the psychosocial environment, which Walberg (1987) defined as the "atmosphere of the class as a social group that potentially influences what students learn" (p. 553). Moos (1974) reported that three broad dimensions can be used in conceptualizing diverse psychosocial environments: (1) relationships (nature and intensity of personal relationships within the environment); (2) personal development (basic directions along with personal growth happens); and (3) system maintenance and change dimensions (extent to which the environment is orderly, clear in expectations, control-oriented, and responsive to change). This conceptualization clearly includes the pattern of relationships and interactions between students and students and teacher and students. A different categorization of climate factors has been posed by Fraser (1980). In his review of numerous studies, Fraser (1980) concluded that classroom environment factors can be clustered into three broad dimensions: task orientation or completion of educational and personal tasks; affective and social relations among class members; and organization of the classroom work.

Relationships between Classroom Climate and Student Outcomes

Over the past several decades, international research efforts involving the conceptualization, assessment, and investigation of classroom environments (synonymous with "classroom climate") have firmly established classroom learning environments as a thriving field of study (Fraser, 1981a, 1981b; Fraser & Walberg, 1981; Walberg, 1979). A common feature of this research is that classroom climates have been assessed through use of student perceptions or "high inference" measures of psychosocial environments (Chavez, 1984). Consequently, an extensive

literature reveals that students' perceptions of psychosocial characteristics of classrooms have important influences on student achievement, performance, and self-conception as well as other educational outcomes (Anderson & Walberg, 1974; Moos, 1979b; Haertel et al. 1981; Chavez, 1984; Fraser, 1986a, 1986b; Walberg, 1987; Creemer & Tillema, 1987-88; Van der Sijde, 1987-88).

Investigations of associations between students' cognitive and affective learning outcomes and perceptions of psychosocial characteristics of classes have produced findings that are surprisingly consistent (Fraser, 1981b). Research findings using high-inferences measures indicate that psychosocial environments of classroom are strongly associated with both achievement and attitudinal outcomes (Fraser et al., 1982). The general nature of the relationship is that student perceptions of psychosocial properties of classes have been found to account for appreciable amounts of learning outcome variations beyond that attributable to student entry characteristics (Anderson & Walberg, 1974; Fraser, 1981b; Fraser et al., 1982; Walberg & Haertel, 1980). For example, two major reviews of research related to the classroom environment report that student perceptions of classroom environments accounted for between 13% and 46% of the variance in cognitive, affective, and behavioral outcomes (Anderson & Walberg, 1974, Haertel et al., 1981). Anderson and Walberg (1974) reported that IQ generally accounts for no more than 16% of the variance in learning, when the effect of pretest scores has been removed. A meta-analysis reported by Haertel and associates (1981) concluded that classroom environment perceptions contribute to a greater or lesser degree in accounting for variance in learning outcomes beyond that explained by ability and pretest measures. Moreover, they report that the signs and magnitudes of the correlations are surprisingly consistent across the studies.

Supporting the general importance of psychosocial environments on student outcomes is Moos's (1980) analysis of the major types of class environments. By using cluster analysis of data obtained in 200 classes, Moos identified six basic types of classrooms and offered the following conclusions concerning the relationship of these classroom types to student outcomes: classes oriented towards relationships and innovation enhance social growth and personal growth, but do less well in improving achievement scores; classes that emphasize goal accomplishment and classroom maintenance produce high achievement but are associated with lower student interests, morale, and creativity; control-oriented classrooms lead to student dissatisfaction and alienation and are not related to personal, social, or academic growth; and classrooms that combine warm and supportive relationships with an emphasis on academic tasks and accomplishments, and an orderly and well-structured milieu, are associated with achievement gains, creativity, and personal growth. Major classroom environment factors found to be related to students outcomes can be classified into three broad dimensions by Fraser (1980). These are as follows.

Task orientation. Task orientation, or emphasis given to efficient completion of learning tasks within a class, has been shown to have a definite relationship with student outcomes. Findings regarding task orientation have been reported in several studies. Moos (1974) reported that achievement in high school mathematics classes was related to high difficulty. Moos (1979) also reported that primary grade students make the greatest gains in reading and mathematics in classes perceived as task oriented. Talmage and Walberg's (1978) found perceptions of greater classroom competitiveness to be associated with lower reading achievement scores. In a meta-analysis by Haertel et al. (1981), goal direction, task difficulty, and competition were positively associated with gains in learning in several subject areas (Haertel et al., 1981).

Affective and social relations among class members. In Anderson's (1970) study, a large number of statistically significant relationships occurred between such climate dimensions as class cohesiveness, cliqueness, and friction and learning outcomes. Group cohesiveness was found to effect individuals differentially by sex and level of mental ability. The findings suggest that classroom social climates have significant effects on individual learning and that there exist wide differences in these effects on students differing in ability and sex (Anderson, 1970). Various variables associated with affective and social relationships in classes such as cohesiveness and satisfaction have been positively related to gains in learning in several subject areas, while factors such as favoritism, friction, cliqueness, and apathy have been found to be negatively associated with learning (Haertel et al., 1981; O'Reilly, 1975). Moos (1974) found that achievement in high school mathematics was related to high class cohesion and low favoritism, friction, apathy, and clique formation. Later, Moos (1979b) found that primary grade students made the greatest gains in reading and mathematics in classes perceived as warm. Moos and Moos (1978) found substantial relationships existing between student and teacher perceptions of classroom environments and mean class grades. For student perceptions, three factors (involvement, affiliation, and teacher support) had significant correlations with mean grades.

Organization of classroom work. The implicit and explicit system of rules and organization of classes have been found to be related to student outcomes. Moos (1979b) reported that primary grade students made the greatest gains in reading and mathematics in classes perceived as systematic and orderly. Haertel et al. (1981) reported that formality, democracy, environment, and organization were positively associated with gains in learning in several subject areas. Fisher and Fraser's (1983) found that emphasizing classroom order and organization is likely to have positive influence on student achievement in several subjects. Gains in

learning were found by Haertel et al. (1981) to be negatively associated with disorganization, speed, and diversity. However, rule clarity and teacher support have been reported to be negatively correlated with mean grades (Moos & Moos, 1978).

Methodological Concerns/Criticisms

Despite a literature associating classroom context factors and student outcomes, theoretical and methodological limitations of the research have undermined the credibility of the findings. The major methodological problems with the past school and classroom effects research have been associated with the units of analysis selected for study and failures to deal with numerous multi-level confounding variables and their interactions (Raudenbush & Willms, 1991). Since educational institutions typically are organized hierarchically, educational data are multilevel in nature. When researchers ignore the hierarchical structure of such data, problems may result from aggregation bias (Burstein, 1980a; Cronbach & Webb, 1975; Hannan, 1971; Haney, 1980; Robinson, 1950), misestimation or imprecise estimates of regression coefficients (e.g., large error variance, unreliable coefficients), and failure to account for within-group variability and interactive effects across levels (Aitkin, Anderson, & Hinde, 1981; Knapp, 1977).

In terms of units of analysis, prior studies on class climate have used three different combinations of units: individual student perceptions and individual learning outcome measures (e.g., Walberg & Anderson, 1968); class average perceptions and class average learning outcome measures (e.g., Anderson & Walberg, 1968); and class average perceptions and individual outcome measures (e.g., Anderson, 1970). Units of analysis typically used in class environmental research have been either individual students or groups (classes, schools or subgroups) (Fraser, 1981a; Haertel et al., 1981). Use of single units of analysis is believed to have resulted in

misestimated precision, which is a threat to valid statistical inference (Raudenbush & Bryk, 1988). Student-level analyses ignore differences in class contexts in which learning occurs whereas class-level analyses ignore variability among students within classes. On the other hand, group-level analyses limit the drawing of valid statistical inferences because of aggregation bias (Raudenbush & Bryk, 1988). For example, stronger outcome-environment associations have been found when classes were the unit of analysis than were associations reported when individual students were used (Fraser & Fisher, 1982). These differences resulted, it is believed, because variables have different meanings at different levels, they are measured with different degrees of precision, and because of the non-random process by which students are assigned to schools and classrooms (Burstein, 1980a). Both Cronbach (1976) and Burstein (1980) have noted that choosing one or the other as a unit of analysis is inappropriate because variations at each level are potentially of interest and ought not to be ignored. They claim that the use of single-level analytical models to study multilevel phenomena can produce misleading results.

The presence of confounding variables at different levels of schooling was viewed by Anderson (1982) as a fundamental problem in studying both school and class climates. The problem is associated with differences in outcomes which cannot be clearly assigned to either group (school or class) context or to the nature of students as individuals, since student background factors are confounded with group (school or class) variables. She suggests that significant relationships between class climate and student outcomes can be distorted if one does not consider student level variables within group contexts. Therefore, Anderson (1982) suggested that model specifications incorporate both individual and group properties. More recently, Raudenbush and Willms (1991) have suggested that the

problem of confounding must be addressed if our understandings of the contributions these variables make to student outcomes are to be enhanced.

The failure to account for interactive effects across levels in the past classroom environment research was recognized by Moos (1979c) who noted that classroom environments in the past research were generally credited with variance added after the effects of personal characteristics have been accounted for. While he believed that this added variance reflects only a portion of the outcomes that can be predicted from environmental characteristics and suggested that environmental factors may also influence the portion of outcome variance predictable from personal characteristics (Moos, 1979c). There is reason to anticipate that relationships between student attributes and outcomes will vary systematically across classes, in part, because of cross-level interactions (Burstein et al., 1989). It is reasonable to anticipate that class-level variables may modify the effects of student background variables and differentially influence student outcomes. The distribution of outcome as a function of ability, sex, race, and socioeconomic status, for example, may be parametrized by the partial regression coefficients of these variables within each group (Burstein, Miiller, & Linn, 1981). Hence, an adequate analysis requires first an estimate how much these coefficients vary across groups and then explanation of why they vary (Raudenbush & Bryk, 1988). Since regression slope heterogeneity has been treated as nuisance instead of the thing to be explained in traditional statistical models, "the differential effect of climates on different individuals within them have not been considered in any depth except at the theoretical level" (Anderson, 1982, p. 411).

Investigations of cross-level interactions could not, however, be undertaken in the past because adequate statistical methods were not available. Recent advances in statistical theory and the development of

computer software now make such investigations possible. New approaches, known as multilevel or hierarchical linear models (Raudenbush & Willms, 1991), seek to account for the complex processes believed to be at work in educational settings and hold promise for modeling various effects so that the interface of individuals and groups can be examined and appropriate implications made (Burstein et al. , 1989).

Assuming perfect measurement and identification of true (major) determinants at both individual and group levels, Burstein and his associates (1989) characterized the classroom research reality with the multilevel perspective as seeking to relate systematically students' background characteristics to performance with a given context; identifying relationships which vary systematically across contexts due to characteristics of learning settings or impact of the learning settings; and determining the random variability present in micro relations in addition to systematic-variability.

A central purpose of multilevel analyses of educational data has been to explore the possibility that educational policies and practices may modify the distribution of outcomes within schools or classrooms (Raudenbush & Bryk, 1986, 1988; Lee & Bryk, 1989). Through the use of hierarchical linear models (HLM), each group's (i.e., school or class) distribution of achievement, represented by effects of student background variables and each group's mean achievement, can be explained as a function of group level variables.

Purpose of the Study

The purpose of the study was to construct a multilevel analytic model to specify relationships existing between class climate factors and mathematics achievement of fourth grade students in selected Tennessee's public elementary schools. Class climate variables were measured by the Tennessee Classroom Climate Inventory (TCCI) (Butler & Alberg, 1989) and

mathematics achievement assessed by the Tennessee Comprehensive Assessment Program (TCAP).

To determine if class climate factors were significantly related to mathematics achievement two research questions were posed:

1. What effects do selected class climate factors have on class average mathematics achievement with student background variables controlled statistically ?

2. Do class climate variables account for differences observed in relationships between selected student background variables and individual mathematics achievement ?

The inquiry was built upon previous research and utilized recent procedural improvements in analyzing multilevel data. The conceptual and analytical schemata utilized represent an alternative way of assessing the effects of class climate on student achievement. The conceptual plan sought to represent variables having theoretical relevance within a mathematical model reflecting the multilevel nature of educational data. Along with class climate variables used as class-level predictors, the inquiry explored several student variables demonstrated in prior research to be predictors of mathematics achievement. The analytical procedure employed sought to take the multilevel structure of educational phenomena into account, explain variations within and between levels, estimate cross-level interactions, and test the fit of class climate effect models.

METHOD

The study consisted of two phases. In the first phase, factor analysis was used to construct scales that represented influential dimensions of class climate. Subsequent analyses were performed at both student and class levels to estimate the reliabilities of the class climate scales selected

for use in the model. In the second phase, assessment of the effects of class climate factors as class-level predictors of mean levels of mathematics achievement and of relationships between student achievement and background variables were conducted. This section contains a description of the data, variables of analyzed, and statistical procedures used.

Data and Sample

Class climate and student background data used in this study were obtained through an instrument developed for a Learning Environment Information System (Butler, 1990) utilized in a school reform effort known as Positive Attitudes in Tennessee Schools (PATS). The project is a Tennessee school reform initiative of the Tennessee State Department of Education and the Center for Research in Educational Policy at Memphis State University. The purpose of PATS is to improve school learning environments through informed decision-making over a five-year period using school leadership teams with state-level coordination (Butler & Alberg, 1989; Butler, Alberg, McNelis, Pike, & Chandler, 1990).

The Tennessee Classroom Climate Inventory (TCCI) (Butler & Alberg, 1989) was developed to yield quantitative measures of class climate factors with survey-type perceptual data obtained from students. Class climate data used in this study were obtained during the spring semester of 1990.

The Tennessee Comprehensive Assessment Program (TCAP) is used to assess achievement of students in Tennessee public schools. Achievement data for students enrolled in PATS Project schools during the 1989-90 school year were provided by the Tennessee State Department of Education on data tape. The TCAP uses a combination of norm-referenced and criterion-referenced measures to determine educational progress of students in grade 1 to 8. CTB/McGraw-Hill customized the CTBS-4

Achievement Test Battery for use by the State of Tennessee. The first TCAP tests were administered statewide during the 1990 Spring semester. Mathematics achievement data for the fourth grade students used as outcome measures in the study were collected in the spring semester of 1990.

Students' identification numbers were used to match the records contained in these two data sets. As a result, selected data for a sample of fourth grade students in the two data sets were merged. The constructed data base included measures of background characteristics of students (i.e., sex, race, and participation in the federal lunch program), mathematics achievement scores, and responses to the 44 items of the TCCI.

Incomplete students records were deleted from the file with the resulting sample being 875 fourth grade students enrolled in 42 classes in 13 schools. Deletion of a case was typically due to missing student background information. Student samples per class ranged from 10 to 28, with the average size per class being 21 students.

Variables of Interest

Mathematics achievement. The rationale for selecting mathematics achievement scores as the outcome measure for this study was based on research indicating that mathematics learning tends to be restricted to the school context while reading and verbal skills are learned both in school and at home (Murane, 1975). Murane (1975) suggested that differences in class environments have greater impact on mathematics than reading achievement. Thus it seems that class climate factors held promise for explaining between-class variability in mathematics achievement.

TCAP scores for mathematics achievement are reported separately for computation, concepts and application, and total mathematics, a combination of scores of math computation, concepts, and application.

Four kinds of scores are reported on achievement data tape for each of the three categories: raw score, scale score, grade equivalent score, and normal curve equivalent score. Normal curve equivalent scores for total mathematics were selected as the measure of student achievement used in the study. Normal curve equivalent scores ranged from a low of .01 to a high of .99. Decimal points were omitted in the analyses.

Student variables. Measures of student background characteristics used in this study are gender, race, and participation in federally-subsidized school lunch programs, which served as an indicator of socioeconomic status. These variables were used as covariates at the student-level.

To facilitate statistical computation, student background measures were recoded as "dummy" variables (i.e., with 0 and 1 coding). The coding was as follows: gender (0 = male, and 1 = female), race (0 = minority, and 1 = whites), and school lunch program participation (0 = students on federally-subsidized lunch program, and 1 = students not on federally-subsidized lunch program). After class mean scores were calculated the values for individuals were then centered around class means. This was achieved by subtracting the class mean from each observation. The purpose of centering was to make the regression coefficients more interpretable. Consequences of this centering techniques will be discussed later.

Student variables constitute an important class of predictors in the multilevel analyses. The correlation coefficients, calculated by the SPSS program (SPSS Inc., 1988), showing the relationships among the background variables are shown in Table 1.

Table 1

Correlations Coefficients for the Student Variables

	Gender	Race	SES
Gender	-		
Race	.19**	-	
SES	.01	.05	-

Note. ** two-tailed significance $p < .01$.

A statistically significant positive correlation exists for gender and race ($r = .19$), indicating that this fourth grade sample contains a higher percentage of minority males than females. Table 1 shows low correlations among the student variables, indicating collinearity should not be a problem in other analyses.

Class-level variables. Class-level explanatory variables utilized were class climate factors measured by the elementary form of the Tennessee Classroom Climate Inventory (TCCI) (Butler & Alberg, 1989). The TCCI contains 44 items that solicit students' perceptions of 11 dimensions of classroom climate: cohesiveness, equality, curriculum, difficulty, communication, evaluation, physical environment, order, instruction, culture, and satisfaction. Items are structured to yield Likert-type ratings of always false to always true (1-5) (Butler, 1990).

An exploratory factor analysis was conducted to identify the underlying factor structure of the TCCI. The resulting factors were used to generate mean estimates of class climate constructs. Principal components analyses were chosen as the factor analysis strategy because it summarizes data by means of a linear combination of observed responses. The intent was to determine response homogeneity, as proposed by Kim and Mueller (1978), which reveals the underlying causal structure, if such a structure exists. Thus the objective is not to explain correlations among variables (as

is the case with common factor analysis), but to find the most distinct response patterns (i.e., partitions) in the data set. Principal components analyses were performed using SPSS (SPSS Inc., 1988) computer program.

Following principal components analyses of the class climate data, the extracted factors were rotated with varimax, oblique, quartimax and equamax methods on six, five, four, and three factor solutions, respectively. Although nine factors were identified with eigenvalues above one, it was decided not to extract more than six factors since a smaller number of factors were expected to produce more reliably consistent scales at the class level (Rowan, Raudenbush, & Kang, 1991).

A comparison of six, five, four, and three factor solutions indicated that the four factor solution with equamax rotation method was appropriate since it is empirically and theoretically sound. The results indicated that four independent components define the structure of the class climate measures. The four factors were identified as: Factor 1 - academic orientation, factor 2 - satisfaction, factor 3- class tension, and factor 4 - cohesiveness. Table 2 presents the result of the analysis.

Class climate items with loadings lower than 0.30 were excluded from the resulting factors. This resulted in three items being excluded from the factors: item 15 (loaded .28) in factor 1, item 24 (loaded .24) in factor 3, and item 36 (loaded .22) in factor 4. Examination of the content of the items whose loading ranged from .30 to .33 indicated that three additional items were not related to the meaning of the resulting factors. Thus these were also excluded from the factors. The three deleted items were: Item 3 (loaded .31) in factor 1, item 9 (loaded .31) in factor 3, and item 35 (loaded .32) in factor 4. Thus 6 items were excluded from the resulting factors. As a result, 38 of the original 44 items were retained in the revised scales.

Table 2

Rotated Equamax Factor Loadings for the Initial TCCI Analysis: Four Factor Solution

#	Item	Factor loading
<u>Factor 1: Academic Orientation (13 Items)</u>		
43.	Tests and quizzes are based on the materials discussed in class.	0.54
41.	Most students become involved in class activities.	0.49
44.	Students are learning things in this class which will be useful to them.	0.47
42.	Rules in this class are the same for all students at all times.	0.47
40.	Grades for student work are fair.	0.45
2.	Books and materials students need are available.	0.42
8.	Everyone has a chance to do well in this class.	0.40
4.	Enough time is taken to explain things students don't understand.	0.38
32.	There is enough space for students to work in groups as well as by themselves.	0.38
3.	Students get to know each other in this class.	0.31*
33.	Grades are based on different kinds of assignments and tests.	0.30
28.	Helpful comments are made on students' work.	0.30
15.	Students like to have visitors in this class.	0.28*
<u>Factor 2: Satisfaction (10 items)</u>		
13.	This class is boring.	- 0.50
7.	Students enjoy the class.	0.47
12.	This class really makes students think.	0.46
1.	Students learn a lot in this class.	0.44
19.	This class is a waste of time.	- 0.40
6.	Students and the teacher are proud of the work done in this class.	0.38
14.	Homework for the class helps students learn.	0.38
31.	Activities in this class are well organized.	0.36
23.	This subjects is presented in interesting ways.	0.34
10.	Students know the purpose of the classwork.	0.33
<u>Factor 3: Class Tension (11 items)</u>		
16.	Things are said to students in front of other people that make them feel bad.	0.54
39.	Some students feel left out or ignored.	0.50
17.	Certain students are the favorites in this class.	0.50
37.	Students in this class often feel like giving up.	0.45
22.	Students don't know how they are doing in this class until they get their report cards.	0.41
20.	Students are treated differently because of their family, friends, race, or sex.	0.40
5.	There is a lot of confusion in the class.	0.40
21.	The way some students behave keeps others from learning.	0.36
29.	When parents are contacted about students in this class, it is about a problem.	0.34
9.	Students who can't get along together cause problems for the rest of the class.	0.31*
24.	The subject taught in this class is hard.	0.27*
<u>Factor 4: Cohesiveness (10 Items)</u>		
34.	Students cooperate with each other.	0.49
27.	Students help to decide what will be studied.	0.45
38.	Students look forward to coming to this class.	0.45
18.	Student get to talk with each other about classwork.	0.42
30.	Students are trusted in this class.	0.39
25.	Work from this class is put up for others to see.	0.36
26.	Students respect the rights and feelings of others in the class.	0.36
11.	Students generally work with their best friends.	0.34
35.	The room is bright and comfortable.	0.32*
36.	Students don't have to work very hard in this class.	0.22*

"" Items excluded from the analysis reported in this study.

The four scales measuring class climate constructs were named: academic orientation (N = 11), satisfaction (N = 10), class tension (N = 9), and cohesiveness (N = 8). First, responses to negatively worded items were recoded to match the polarity of the other items in the scales. That is, responses for item 13 and item 19 were reversed so that they measured the extent of satisfaction as other items of the satisfaction scale. The four component-based scales were then formed by adding item scores together and dividing by the number of items in the scale. Therefore, the score on any given scale for individual respondents can range from 1 (which would indicate that the respondent strongly disagreed with all scale items) to 5 (indicating strong agreement with all items comprising the scale). This approach was taken to maximize both construct and response homogeneity of the characteristics being measured while at the same time providing class-level variables appropriate for addressing the research questions posed in this study. The four scales used to generate the class climate indicators are described below.

Academic orientation. Items comprising the academic orientation scale solicit responses regarding class activities centered around the accomplishment of specified academic objectives. Items deal with the importance of completing activities, adherence to the subject matter, and a variety of instructional activities such as testing, grading, evaluating, monitoring student progress, providing learning opportunities, and provision of materials for students use.

Class tension. Items that form this scale solicit measures of tension and indicators of poor interpersonal relations in a class. Item contents include teachers treating some students more favorably than others, disregarding students' feelings, lack of clarity, lack of immediate feedback provided for students regarding their progress, and presence of student behaviors that keep others from learning.

Satisfaction. Items comprising the satisfaction scale measure perceptions of enjoyment and positive feelings toward class work. Content of the items focus on student enjoyment of the class, presentation of material, organization of class activities, and extent to which class members reflect pride in their work.

Cohesiveness. This scale measures perceptions of cooperation or collaboration existing among class members. Content of the items include cooperating with each other, helping each other with classwork, respect for each other, being friendly toward each other, cooperating with the teacher, trust placed in students, and students looking forward to coming to class.

Reliability analyses of the four class climate scales were performed at both student and class levels. Student level scale reliability estimates were determined by Cronbach's alpha coefficients which indicate the internal consistencies of the scales. As can be seen in Table 3, student-level internal consistency reliability estimates are: 0.80 for Academic Orientation, 0.81 for Satisfaction, 0.71 for Class Tension, and 0.70 for Cohesiveness. These are acceptable levels of internal consistency for this type of attitudinal measure.

However, since the study involved a multilevel analysis in which class climate measures were used to assess entire classes properties, individual scores must be aggregated to construct class indicators. The reliability of class measures can not be appropriately estimated by alpha coefficients. Therefore, a one-way ANOVA (represented by Equation [1] and [2] in the following section) was performed using the HLM program to decompose variance in the scales into within- and between-class components and to obtain reliability estimates of class means for the four scales. Intraclass correlations (Equation [3] in the following section) were also generated as indicators of how much of the total variance for these scale scores lay within and between classes. The column labeled " ρ_1 " in

Table 3 reports intraclass correlations for these scales. This statistic has two useful and mathematically equivalent interpretations. First, it is the estimated correlation between pairs of scores within the 42 classes used in the study. Therefore, it measures the degree of dependence among the observations sharing a classroom. Second, it estimates the proportion of the total variation in each scale between classes. This proportion ranges from a low of 19% to a high of 22%, indicating the existence of differences in class means on the measures of climate. The final column in Table 3 (labeled W_j , see Equation [4] in the following section) reports the class level estimates of reliability for each scale. The coefficient (W_j) represents the reliability of the classes' sample means as four scales estimates of their true means. These point estimates of reliability range from a low of .83 to a high of .85, indicating that, at the class level, all class climate scales are sufficiently reliable for the purpose of this study.

Table 3
Reliability Estimates for Final Set of Scales

Scales	# of Item	Alpha	ρ_1^*	W_j^{**}
Academic Orientation	11	.80	.19	.83
Satisfaction	10	.81	.20	.83
Class Tension	9	.71	.19	.83
Cohesiveness	8	.70	.22	.85

* ρ_1 = Intraclass correlation estimates from HLM analysis.

** W_j = class level reliability estimates from HLM analysis.

As a preliminary step to subjecting the data to HLM analysis, simple bivariate relationships of the four scales were generated. The results of this correlational analysis used in later interpretation of the HLM results. Correlations coefficients for the scales are shown in Table 4. Results show

that low to moderate zero order correlations exist among the scales, indicating moderate collinearity between some scales. This did not seriously affect the results of the HLM analyses.

Table 4

Correlation Coefficients for the Class Climate Scales

	Academic	Satisfaction	Class Tension	Cohesiveness
Academic Orientation	-			
Satisfaction	.68**	-		
Class Tension	-.38**	-.40**	-	
Cohesiveness	.56**	.61**	-.35**	-

Note. ** two-tailed significance $p < .01$.

Statistical Analysis Procedures

In addressing the research questions posed, a multilevel analysis of the data was conducted using the HLM computer program developed by Bryk, Raudenbush, Seltzer, and Congdon (1989). The empirical development of a predictive model of class climate effects on student mathematics achievement was accomplished by use of a two-level hierarchical linear model. This model involved two distinct operations. First, in the within-class model, summarized by the within-class equations, mathematics achievement scores were regressed on the student variables, from which the effects of these variables on mathematics achievement could be estimated. This procedure yielded separate parameters (intercept and slopes) for each class in the study. Second, in the between-classes model, parameters yielded in the first stage became outcome variables to be predicted by class climate variables at the class level. In this procedure, an estimate of the effect of class climate variables on mean

class differences of mathematics achievement (i.e., the intercept of the within-class model) and regression coefficients representing the effects of the student variables was determined.

The HLM analysis proceeded in three steps: 1) apportioning variation between and within classes; 2) assessing the homogeneity of the regression assumption; and 3) assessing the effects of class climate factors. Each step built on the previous one, as explained below.

Apportioning Variation. The goal here was to estimate the variation in mathematics achievement test scores existing between- and within-classes. The model can be represented by the equation:

$$Y_{ij} = \beta_{j0} + \epsilon_{ij} \text{ where } \epsilon_{ij} \sim N(0, \sigma^2). \quad [1]$$

This equation states that mathematics achievement test scores for student i in class j are assumed to vary around the class mean, β_{j0} , with within-class variance σ^2 .

The associated between-class model is:

$$\beta_{j0} = \gamma_0 + U_{j0} \text{ where } U_{j0} \sim N(0, \tau) \quad [2]$$

Equation [2] shows the mean for each class, β_{j0} , varies around a grand mean, γ_0 , of all classes in the sample, with between-class variance τ . The combination of both equations is equivalent to a one-way random effects ANOVA with class treated as a random factor.

The HLM analysis provides maximum likelihood estimates of the within-class and between-class variance. With this information an estimate of the intraclass correlation (ρ_I) can be determined using the following formula:

$$\rho_I = \tau / (\tau + \sigma^2) \quad [3]$$

This statistic indicates the degree of dependence among observations in a class and provides an estimate of the total variation in mathematics achievement scores between classes (with no control for covariates).

With four class climate factors used as outcome measures replacing Y_{ij} in Equation [1], then Equation [1] and Equation [2] yield estimates of variation in class climate factors laying within and between classes. In this case, Y_{ij} in Equation [1] represents the score on a class climate factor for student i in class j ; β_{0j} is the mean of the factor for class j ; and ϵ_{ij} is a random error term that is normally distributed with mean 0 and variance σ^2 . The equation simply shows that individuals' ratings of class climate factors vary around the class mean with variance σ^2 . In turn, Equation [2] states that the class means on aggregate class climate factors are normally distributed across the classes with a grand mean γ_0 and variance τ .

Using the one-way ANOVA model (Equation [1] and [2]), student's perceptions on class climate factors divided into within-class and between-class components, thus providing the intraclass correlation coefficients represented in Equation [3]. When the intraclass correlation coefficient is large, responses of individuals within the same class are highly correlated, and a large percentage of the total variance in the class climate rating is between classes.

The one-way ANOVA model also provides a measure of the reliability of estimated class means on class climate factors. That is, the analysis provides class-level reliability estimates of the four class climate factors. Estimates of σ^2 and τ from Equations [1] and [2] are

provided and the program computes a ratio for each class, which is denoted as W_j ,

$$W_j = \tau / (\tau + \sigma^2 / n_j) \quad [4]$$

where n_j is the sample size for class j (see Bryk et al., 1986). This ratio (W_j) is analogous to the reliability coefficient of classical measurement theory, where reliability is defined as the ratio of "true" score variance to total observed variance in a measure (Rowan et al., 1991). This ratio is a function of the amount of between-class variance in scores relative to within-class variance and of the size of a class sample.

Finally, the one-way ANOVA model provides a Chi-Square test of significance to evaluate the hypothesis of no differences in mean mathematics achievement or class climate factors among classes in the sample (Hypothesis 1).

Assessing Homogeneity of Regression. In the next stage, student-level variables were added to the within-class model. In this study the expanded within-class model was as follows:

$$(\text{Math})_{ij} = \beta_{j0} + \beta_{j1}(\text{Gender})_{ij} + \beta_{j2}(\text{Race})_{ij} + \beta_{j3}(\text{SES})_{ij} + \epsilon_{ij}. \quad [5]$$

In order to facilitate interpretation and computation, student-level variables were centered around class means. The centering technique results in the intercept β_{j0} representing class mean achievement adjusted for background characteristics (i.e., the raw class mean minus the mean of the student-level independent variables). β_{j1} , β_{j2} and β_{j3} represent the differentiating effects of student level variables on mathematics achievement test scores in class j , which can be interpreted as the degree to which differences in student-level predictors (e.g., gender) relate to differences in fourth-grade mathematics achievement.

In the unconditional between-class model, interest centered on determining whether there was a significant regression effect of the k student variables on mathematics achievement within classes, as well as the extent of variation of these effects across classes. In this procedure, each regression coefficient, β_{jk} , given in equation [5], was in turn modeled as:

$$\beta_{jk} = \mu_k + U_{jk} \quad \text{for } k = 0, 1, 2, 3. \quad [6]$$

The μ_k represent the fixed main effects (the mean within-class regression coefficients for variable k across classes in the sample) while U_{jk} are random effects which vary across classes. The results of the analysis provided a test of the hypothesis of no variation across classes in their regression coefficients (Hypothesis 2). The hypothesis is stated as:

$$H_2: \text{Variance } (\beta_{jk}) = 0$$

If this hypothesis can be rejected for any of the four regression coefficients (an intercept and three slopes), the regression coefficient rejected can be said to have changed significantly as a function of the class in which a student is enrolled. Therefore, the coefficient should be modeled as a random effect. If the hypothesis is retained, then variables found not to have a significant effect on student mathematics achievement can remain in the model as a fixed effect. This analysis determines which student variables are significantly related to achievement and whether relationships vary across classes.

Assessing Effects of Class Climate Factors. In the final step, student variables having no effect on mathematics achievement test scores were dropped from the model. The between-class model at this stage was elaborated to include the effects of class climate factors. Equation [7]

provides an illustrative example of a possible between-classes model for the intercept from the within-class equation (Equation [5]).

$$\beta_{j0} = \gamma_{00} + \gamma_{01}(\text{Academic Orientation})_j + \gamma_{02}(\text{Satisfaction})_j + \gamma_{03}(\text{Class Tension})_j + \gamma_{04}(\text{Cohesiveness})_j + U_{0j}. \quad [7]$$

Equation [7] indicates that four class climate factors are used to model the intercept. This expanded model tests null hypotheses (3): class climate variables are not related to class mean mathematics achievement; and (5): after explaining variation in class mean mathematics achievement by class climate variables, no explainable variation in means will remain.

All four class climate factors were used to model the slopes for student variables in the within-class model for mathematics achievement. This analysis determined if class climate factors interacted with selected student variables and their relationship to student achievement.

The equation was:

$$\beta_{jk} = \gamma_{0k} + \gamma_{k1}(\text{Academic Orientation})_j + \gamma_{k2}(\text{Satisfaction})_j + \gamma_{k3}(\text{Class Tension})_j + \gamma_{k4}(\text{Cohesiveness})_j + U_{kj}. \quad [8]$$

The results of this analysis provided the tests of null hypotheses (4): class climate variables are not related to within class regression coefficients representing the relationship between student mathematics achievement and student variables; and (6): after explaining the variation in within class regression coefficients representing the relationship between student mathematics achievement and student variables by class climate variables, no explainable variation in means on these regression coefficients will remain.

RESULTS

Three sequential steps in conducting the hierarchical linear modeling analyses are summarized and results yielded in testing each hypothesis are reported.

Apportioning Variation

A first step was to determine variance existing between the four grade classes using mathematics achievement and class climate data. A random effects one-way ANOVA model (represented by equation [1] and [2]) was formulated for this purpose. Results yielded by this one-way ANOVA model regarding the mathematics achievement indicated the pooled within-class variance (σ^2) as 441.247 and the between-class variance (τ) as 66.214. Thus, the intraclass correlation, ρ_I , is .130 for mathematics achievement, indicating that 13% of the total variance in achievement is located between classes with no control for any covariates. Conversely, 87% of the variance in the achievement measure is potentially explainable by within-class factors. Interestingly, recall from Table 3 that proportion of total variance in between classes for the four class climate factors ranged from a low of 19% to a high of 22%. A point reliability estimate (W_j) of the class sample achievement means as estimators of true means was found to be .75, indicating that differences among the mathematics class means are reliable estimators of true class means.

An one-way ANOVA was also used to test the null hypothesis of no differences in mean mathematics achievement among classes in the sample. Chi-Square analysis indicated that the hypothesis could be rejected since classes did show significant variability in mean mathematics achievement ($\chi^2 = 170.52$, $df = 41$, $p < .001$, see Table 5). Chi-Square tests of significance were also used to test the hypothesis of no differences in class-level predictors among classes in the sample. Results shown in Table

5 indicate that significant differences among mean class climate variables exist. Thus, hypothesis 1 can be rejected at the .001 level.

Table 5

Chi-Square Results for Mathematics and Class Climate Constructs

Parameter	Estimated Parameter Variance	df	χ^2	p
Mathematics	66.214	41	170.52	<.001
Academic Orientation	.076	41	241.04	<.001
Satisfaction	.094	41	256.94	<.001
Class Tension	.100	41	245.30	<.001
Cohesiveness	.120	41	285.96	<.001

Assessing Homogeneity of Regression for Mathematics Achievements

To improve precision and reduce possible confounding in estimating class climate effects, student background variables were used as covariates. This analysis involved use of an unconditional or random regression coefficient model (Equations [5] and [6]) to estimate total parameter variance in the four random effects (the intercept and three regression slopes), and to examine the appropriateness of the within-class model. Residuals from this model indicated the extent of variability in the random effects across classes and provided a test of the homogeneity hypothesis for each parameter. Results are reported in Table 6.

Table 6

Unconditional Model for Mathematics Achievement

Fixed Effects		Gamma	Standard Error	t	p
For BASE	β_0				
Base		58.07	1.45	40.128	.000
For GENDER slope	β_1				
Base		- 3.79	1.39	- 2.720	.012
For RACE slope	β_2				
Base		18.75	1.61	11.610	.000
For SES slope	β_3				
Base		14.12	1.87	7.568	.000
Random Effects		Estimated Parameter	df	χ^2	p
Base		76.824	41	332.56	.000
Gender Slope		32.397	41	65.83	.008
Race Slope		58.631	41	88.73	.000
SES Slope		96.021	41	133.89	.000
<u>Correlations among Class-Level Random Effects</u>					
		β_0	β_1	β_2	
Base Achievement	β_0				
Gender differentiation	β_1	- .125			
Racial differentiation	β_2	- .019	.162		
SES differentiation	β_3	- .314	.008	.261	
<u>Reliability of Class-Level Random Effects</u>					
Base		.873			
Gender Slope		.380			
Race Slope		.513			
SES Slope		.633			

Gamma coefficients, which estimate the mean regression equation for the 42 classes, provided estimates of the mean fixed effects. Table 6 shows the adjusted mean level of mathematics achievement as 58.07, estimated mean gender effect as -3.79, estimated mean race effect (race slope) as 18.75, and average SES differentiation effect (SES slope) as 14.12. All are statistically significant ($p < .05$). Results indicate that race ($t = 11.61$) and socioeconomic status (i.e., SES) ($t = 7.57$) have stronger effects than does gender ($t = -2.720$) on mathematics achievement. Gender is negatively related to mathematics achievement (gamma = -3.79) indicating that girls achieved less than boys. The positive coefficient for race (gamma = 18.75) indicates that minority students performed less well than white students. The positive coefficient (gamma = 14.12) for SES reveals that students who do not participate in the school lunch program achieved a higher level in mathematics than did lower SES students.

Table 6 provides a numerical indication of distributive class effects, expressed as correlations among class-level random effects. Results indicate that classes with high mean achievement are associated with smaller achievement differences between higher SES and lower SES students ($r = -.314$), smaller differences between minority and white students ($r = -.019$), and smaller differences between male and female students ($r = -.125$). Also revealed is a positive association of SES and racial differentiating effects ($r = .261$).

Information about the reliability of the random effects in the model is also reported in Table 6. These reliability indicators were derived from the ratio of estimated parameter variance in each regression coefficient to the total observed variance in the corresponding estimated OLS slope. Results indicate that achievement estimates are reliable, with more than 87% of the variation in achievement potentially explainable by class-level predictors with less than 13% due to sampling variability (noise). As expected, regression coefficients associated with student variables are less

reliable, ranging from .38 for gender to .63 for SES. For example, class-level reliability of .38 for gender indicates that approximately 62% of the variation is attributable to sampling variance and not explainable by class-level predictors.

Table 6 also reports results of the homogeneity of variance tests which provide evidence of significant variations among classes for each of the four random regression coefficients. The coefficients indicate that base, gender, SES, and race can be treated as random since significant variations among classes are presented. The probability of the observed variability in these coefficients, under a homogeneity hypothesis, is less than .001 for β_{j0} , β_{j2} , and β_{j3} , and less than .01 for β_{j1} . Therefore, null hypothesis which stated that the within class regression coefficients representing the relationship between student mathematics achievement and student variables will be the same for each class can be rejected. The effects of gender, race, and socioeconomic status as well as mathematics achievement varied significantly from class to class. These variations signal a violation of the homogeneity assumption of within-class regression relationships in traditional regression analysis. Variations existed for within-class mean achievement, or intercept, when the student variables were controlled. Variations existed for within-classes slopes indicate that class contexts influence achievement differently, depending upon student background factors. Said another way, class climate variables mediate relationships existing between student variables and achievement. The next task was to determine which climate variables contributed to these between-class differences.

Assessing the Effects of Class Climate Variables on the Distribution of Mathematics Achievement

Using results of analyses of class mean achievement and relationships between student variables and achievement as they varied

by class, this multilevel analysis involved creating an explanatory model to determine which class climate factors contributed to achievement and changes in the strength of associations between student variables and achievement. Therefore, the unconditional between-class models were extended to include climate variables in order to explain the differential between-class variations. The explanatory model reflects class climate effects with four climate factors used to model the Base and slopes of three background variables. Results yielded by this model are presented in Table 7.

Presented in Table 7 are the results of the effects of the class climate variables on either the intercept or slope coefficients of the student variables. Table 7 shows that academic orientation is positively related to mathematics achievement, after adjusting for student variables ($\gamma = 23.51$, standard error = 10.82, $t = 2.174$, and $p < .05$). That is, classes with stronger emphases on academic tasks are associated with higher levels of mean achievement. Satisfaction, cohesiveness, and class tension, however, are not significantly related to class mean achievement ($t = -1.87, -1.17$, and 1.15 respectively). Therefore, barring any serious problems with fit of the model, we retain hypothesis 3 for satisfaction, class tension, and cohesiveness and reject the hypothesis for academic orientation. The conclusion is that academic orientation of classes is significantly related to class mean mathematics achievement.

Academic orientation was also found to be positively related to the differentiating effect of gender on achievement (gender slope) ($\gamma = 23.67$, standard error = 10.40, $t = 2.28$, and $p < .05$). Thus gender differentiation effects were present in classes where higher academic emphases existed, indicating that achievement differences of male and female students was larger in classes with stronger academic emphases.

Table 7

Explanatory Model for Mathematics Achievement

Fixed Effects		Gamma	S. E.	t	p
For Base β_0					
Base		40.812	38.429	1.062	.222
Academic		23.506	10.815	2.174*	.042
Satisfaction		-22.480	12.036	-1.868	.072
Class Tension		- 6.251	5.335	-1.172	.196
Cohesiveness		7.286	6.288	1.159	.199
For Gender slope β_1					
Base		- 113.921	37.243	- 3.059*	.007
Academic		23.670	10.400	2.276*	.035
Satisfaction		-18.116	11.522	-1.572	.116
Class Tension		17.256	5.226	3.302**	.004
Cohesiveness		10.498	6.081	1.726	.091
For Race slope β_2					
Base		- 118.045	44.957	- 2.626*	.017
Academic		9.402	12.305	.764	.292
Satisfaction		12.771	13.454	.949	.249
Class Tension		13.647	6.192	2.204*	.040
Cohesiveness		3.399	7.226	.470	.352
For SES slope β_3					
Base		85.518	51.800	1.651	.103
Academic		16.989	14.266	1.191	.192
Satisfaction		-37.141	15.698	-2.366*	.029
Class Tension		-4.087	7.117	-.574	.332
Cohesiveness		3.729	8.358	.446	.356
		Estimated			
Random Effects	Parameter	Variance	df	χ^2	p
Base	β_0	60.388	37	244.56**	.000
Gender	β_1	17.150	37	49.71	.079
Race	β_2	38.676	37	69.05**	.001
SES	β_3	71.435	37	98.98**	.000

* p<.05.

** p<.005.

In addition, class tension was positively related to the gender differentiation effect on achievement (gender slope) ($\gamma = 17.26$, standard error = 5.23, $t = 3.30$, and $p < .005$), indicating that achievement differences between male and female students was larger in classes with high levels of tension. Conversely, less class tension had less differentiating effects of gender on mathematics achievement. These findings demonstrate effects these two climate factors have on equity in schooling. Satisfaction and cohesiveness had no significant effects on gender slope, indicating that no cross-level interactions between these two factors and gender. Therefore, hypothesis 4 is retained for satisfaction and cohesiveness and it is inferred that these two factors are not significantly related to the relationship between gender and achievement. Hypothesis 4 can be rejected for academic orientation and class tension which are significantly related to the relationship between gender and achievement.

Class tension was found to be positively related to the differentiating effect of race on achievement ($\gamma = 13.65$, standard error = 6.19, $t = 2.20$, and $p < .05$). Higher levels of class tension were associated with greater achievement differences of minority and white students. Conversely, lower levels of class tension were associated with reduced achievement differences of white and minority students. Thus classes with less tension differentiate less in converting racial characteristics into differences in mathematics achievement. Academic orientation, satisfaction, and cohesiveness, on the other hand, were not associated with the race slope, indicating that interactions do not exist between racial differentiation effects and these climate variables. Therefore, hypothesis 4 was retained for academic orientation, satisfaction, and cohesiveness. Hypothesis 4 is rejected for class tension which had a significant effect on the relationship between achievement and student race.

Satisfaction was found to have a strong negative effect ($\gamma = -37.14$, standard error = 15.70, $t = -2.37$, and $p < .05$) on the differentiating

effect of socioeconomic status (SES slope), indicating that classes with higher levels of student satisfaction reduced the differentiating effect of socioeconomic status on achievement. That is, higher levels of student satisfaction were associated with smaller differences in achievement between students of higher SES and lower SES students. This suggests that achievement of lower SES students is more like their advantaged counterparts in classes with higher levels of satisfaction. Academic orientation, class tension, and cohesiveness, however, had no significant effects on the differentiating effect of SES on achievement. Therefore, hypothesis 4 was retained for academic orientation, class tension, and cohesiveness and rejected for satisfaction.

Chi-Square analyses were used to test the hypotheses (hypotheses 5 and 6) regarding whether residual differences among classes in a particular within-class parameter (either intercept or slopes) can be attributed to nothing more than sampling variance. The χ^2 statistics of 224.56 ($p < .001$) indicates that hypothesis 5 can be rejected for mean achievement. Thus, after explaining variation in mean achievement by climate variables, some significant variation remained.

Similarly the χ^2 tests of the hypotheses that the residual variances in β_{j2} and β_{j3} yield test statistics of 69.05 ($p < .01$) and 98.98 ($p < .001$) indicates that variance remains unaccounted for in these two slopes. That is, after accounting for the effects of class-level predictors, the slopes still differed. Therefore, hypothesis 6 is rejected for race and SES. The hypothesis for gender differentiation, however, is sustained ($p = .079$, see Table 7), since, after explaining the variation between achievement and gender by climate variables, no explainable variation in means on the gender slope remained. However, this was due to the fact that the gender slope had the lowest level of reliability ($W_j = .38$, see Table 7), indicating that only 38% of the total variation is explainable by class-level variables.

Table 8 summarizes the changes in estimated four parameter variance for the random effects from the unconditional model to the explanatory model in the between-classes model estimated by HLM. Differences between two estimates, expressed as a proportion reduction in parameter variance, $\%R^2$, relative to the unconditional model, are also presented in Table 8.

Table 8
Summary of Results for Distribution of Mathematics Achievement Analyses

Model	BASE		GENDER		RACE		SES	
	Var(β_0)	$\%R^2$	Var(β_1)	$\%R^2$	Var(β_2)	$\%R^2$	Var(β_3)	$\%R^2$
Unconditional	76.824		32.397		58.631		96.021	
Explanatory	60.388	21.4%	17.150	47.1%	38.676	34.0%	71.435	25.6%

Note. $\%R^2$ represents the percentage of variance accounted for by the explanatory model (using the Unconditional model as a baseline).

Results in Table 8 indicate that the explanatory model accounts for a substantial percentage of the variance in the four parameters. The parameter variance of the random effect for achievement (residual parameter variance) is 60.39 which is a 21.4% reduction as compared to its unconditional model (76.82). This reveals that four class climate factors in the explanatory model account for more than 21% of the explainable variance in achievement after controlling for the student variables. The explanatory model reduced the estimated parameter variance for gender from 32.40 to 17.15, a change of 47.1%. Corresponding changes for race and SES slopes are 34% and 25.6% respectively. Thus the explanatory model provides a better fit for the data than does the unconditional model

and provides evidence that climate factors have a substantial impact on the distribution of fourth grade mathematics achievement.

However, random effects indicated by Chi-Square tests reported earlier reveal that there remains unexplained significant residual variations in mean achievement, along with the effects of race and SES. Therefore, other important variables for predicting achievement exist. However, the increase in estimated variance explained for gender differentiation by this explanatory model indicates climate variables are important factors for explaining differences in achievement of boys and girls.

SUMMARY AND CONCLUSIONS

Research question 1

What effects do the class climate factors have on class average mathematics achievement with student background variables controlled statistically?

The analyses addressing the first research question indicate that, after controlling for the student variables, only one of the four class climate factors -- academic orientation -- was significantly related to class mean mathematics achievement. Mean mathematics achievement was found to be higher in classes where there exist a strong emphasis on academic tasks. This finding supports Moos's (1979) conclusion that primary grade students make the greatest gains in mathematics in classes that are task oriented. Class tension, student satisfaction, and cohesiveness were not found to effect mathematics achievement, which failed to confirm Haertel and associates' (1980) conclusion that satisfaction and cohesiveness were positively associated with achievement regardless of grade levels and subject areas.

HLM revealed that a small portion of variability (13%) in mathematics achievement was explainable by class-level factors. When student variables were controlled, however, a substantial percentage (21.4%) of variance between classes was explained. This effect was identified in addition to the effects of the student variables. This evidence supports other findings that class climate factors account for considerable variance in academic achievement beyond that accounted for by student characteristics (Fraser et al., 1982; Haertel et al., 1981). HLM also revealed that variance between achievement left unexplained by climate factors is also statistically significant and substantially important suggesting that other class factors contribute to mathematics achievement which are not explained in the explanatory model presented.

Research question 2

Do class climate variables account for differences observed in relationships between selected student background variables and individual mathematics achievement ?

Academic orientation was found to be positively related to the relationship between gender and mathematics achievement. Achievement differences between male and female students were found to increase as ratings of academic orientation increased. Class tension was also found to relate to gender differences in achievement, indicating that differences were larger in classes with high levels of tension. In other words, student gender had a weaker effect on mathematics achievement in classes with low levels of tension. The same pattern was found for the racial differentiation effect, indicating that achievement differences between white students and members of other ethnic groups widens as class tension increases. In other words, higher levels of class tension are associated with increased inequality of achievement for students of different racial groups. In short, high levels of class tension are associated

with disequalizing effects with regard to gender and race. No similar findings are reported in the literature.

The class climate factor of satisfaction, on the other hand, was observed to have a reverse impact on the SES and mathematics achievement relationship. Achievement differences between higher SES and lower SES students narrowed as satisfaction ratings increased, with other factors held constant. High student satisfaction appears to weaken the differentiating effects of socioeconomic status on mathematics achievement, suggesting that the social distribution of mathematics achievement is more equalized in classes where high levels of satisfaction exist. This finding provides evidence that student satisfaction is important in modifying the strength of association between socioeconomic status and achievement. No previous study has reported this finding.

No evidence was found for the effects of cohesiveness on relationships between achievement and three student variables. That is, gender, race, and SES effects on mathematics achievement did not vary among classes due to cohesiveness of the classes. This result does not confirm Anderson's (1970) finding that class cohesiveness has a significant effect on individual learning and that wide differences exist in these effects for students differing in gender (Anderson, 1970).

The explanatory model accounted for a substantial percentage of the variance in the differentiating effects of gender (47.1%), race (34%), and socioeconomic status (25.6%). The variation in gender differentiation effect was adequately explained by the explanatory model. Racial and SES differentiation effects were not fully explained by the explanatory model, however.

Based on these results, higher levels of academic emphases apparently promote higher average mathematics achievement while increasing inequality in achievement between male and female students. That is, achievement differences between male and female students widen

as class ratings on academic orientation increase. This finding was not expected. On the other hand, as anticipated, higher levels of class tension were related to larger achievement differences while increases in student satisfaction were related to smaller achievement differences between student subgroups (i.e., male and female students, white and minority students, lower and higher SES students).

From these findings, a set of tentative conclusions may be drawn. Specifically:

Academic orientation of fourth grade classes is associated with higher academic achievement. Emphasis on academic tasks, however, has a differentiating effect for students on the basis of gender, resulting in an unequal distribution of achievement between male and female students. Class tension and student satisfaction with classes have differential effects due to gender, race, and socioeconomic status. These findings support Anderson's (1970) claim that classroom climates affect learning and affect it differently depending on student characteristics.

Inclusion of four climate factors in the HLM model explained considerable variance in mathematics achievement and the internal differentiating effects of student variables on mathematics achievement, confirming that the distribution of mathematics achievement varies as a function of psychosocial environments of classrooms. Class climate factors appear to have considerable impact on the distribution of fourth grade mathematics achievement. This conclusion appears to support Creemers and Tillema's (1987-88) differential context hypothesis which holds that differences in student performances result primarily from classroom contextual effects. The conclusion also supports Lee's (1986) and Bryk and Raudenbush's (1989) notion that climate or normative environmental factors act as important determinants of distribution of mathematics

achievement. This study demonstrates the importance of class context factors on academic achievement.

Findings indicate that climate factors appear to mediate relationships existing between student characteristics and mathematics achievement and can serve as a catalyst to change student academic achievement in desirable ways. Evidence suggests that reduced class tension is associated with more equality in the distribution of academic achievement of students by gender and racial backgrounds. High levels of student satisfaction, on the other hand, were associated with a reduction of achievement differences between high SES and low SES students. That is, students' positive perceptions toward their classes are related to more equitable social distributions of achievement.

Emerging from this study is a conception of a distinctive class climate that appears to be particularly effective for all students. Higher academic achievement and more equitable distributions of achievement exist in classes which reflect higher levels of academic emphases and student satisfaction, and low levels of class tension. Findings of this study provide an improved understanding of classroom context factors associated with student achievement. These findings support use of class climate assessments for improving educational diagnosis, planning, and intervention strategies.

Methodologically, this study confirms that students can serve as informal observers and that their perceptions can be used in empirically profiling conditions present in classroom social contexts. This study has also confirmed the predictive validity of student perceptions of the psychosocial dimensions of their classes. Results reported here indicate that between-classes variances of achievement exist even after controlling for the student-level variables of gender, race, and SES. Finally, and perhaps most interesting, is that findings yielded by hierarchical linear

modeling methodology documented the presence of between-class variability of achievement and within-class variability of relationships between achievement and student variables. In addition, relationships these variations have with class climate factors were also identified.

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